SPECIAL ARTICLES

ON THE ASSOCIATION AND POSSIBLE IDENTITY OF ROOT-FORMING AND GEOTROPIC SUBSTANCES OR HORMONES IN BRYOPHYLLUM CALYCINUM

RECENT experiments have led me to results which suggest that the substances responsible for root-formation in the stem of *Bryophyllum calycinum* are associated or possibly identical with the substances responsible for geotropic curvatures of the stem of this plant.

1*a*. When we cut out a piece of the stem of *Bryophyllum* and suspend it horizontally in a vessel saturated with water vapor, the stem will bend to such an extent that it assumes the shape of a U, the concave side being on the upper side. It was found that this geotropic curvature is due to a growth (or some other form of active stretching) of the cortex in the convex region of the lower half of the stem. The upper half of the stem is bent passively through the growth of the lower half. This was ascertained by measurements on marked stems split longitudinally, and suspended horizontally.

1*b*. It was found that root-formation appears generally in that node around which the curvature takes place and that it is confined in the bending region to the nodes on the lower side of a horizontally suspended stem. It is thus seen that the geotropic growth (or active stretching) and the root-formation both take place on the lower side and in the same region of the stem.

2*a*. When we cut out a piece of stem from *Bryophyllum* containing from four to seven nodes (but with the two most apical nodes cut off) and if we remove all the leaves such a stem will form roots at the two most basal nodes (and sometimes also at the basal surface) and new shoots at the two most apical nodes, but this new growth is extremely slow. If, however, a leaf is left on the stem the new organs will grow out much more rapidly.

2*b*. When such a stem without leaves is suspended horizontally it will bend geotropically, but the bending will take place very slowly. If, however, a leaf is left on the stem the geotropic curvature takes place with much greater rapidity.

3*a*. When we remove all but one apical leaf on the lower side of such a horizontally suspended stem, the stem will form roots first in the second node from the leaf; but only from the node on the under side of the stem. Roots will also grow out from the two most basal nodes.

3*b*. In the same stem the geotropic curvature will occur in the region where the first growth of roots takes place; namely around the second node behind the leaf.

4*a*. When all the leaves are removed with the exception of one leaf in the basal node (on the under side of the horizontally suspended stem), root-formation will be scant and will only take place at the cut surface at the basal end of the stem behind the leaf; and sometimes also from the axilla of the leaf.

4*b*. In such a stem the geotropic curvature is generally considerably less than when an apical leaf is left and is confined to the piece of internode behind the leaf and to the immediate neighborhood in front of the leaf.

5. In all these experiments the region of curvature (and of growth of the cortex) coincides with the region where the most rapid growth of the roots takes place (or where root-forming substances or hormones collect).

6. The effect of the position of a single leaf on the stem is much more striking when we remove the upper half of the cortex in a horizontally suspended stem of *Bryophyllum*. Such stems become at once very strongly convex on the upper side, due to the release of the passively contracted wood and pith on the upper side, where the cortex is removed. When in such a stem all the leaves are removed except the one on the lower side at the apical end of the stem, the latter will gradually overcome the convexity on the upper side and assume the geotropic U shape with the concavity on the upper side due to geotropic growth of the cortex on the lower side of the stem, in the region around the second node behind the leaf. If, however, the leaf is left at the basal end no geotropic curvature will occur (at least none appeared as long as the stems were observed). If the cortex is removed on the lower side no geotropic curvature is possible since this curva-

ture is due to the growth of the cortex on the lower side of the stem.

7. It is known that the geotropic "stimulus" can travel around a corner, *i. e.*, around an incision through half the thickness of the stem, which is to be expected if the "stimulus" consists in the flow of a liquid. If such incisions are made alternately across the upper and lower half of each internode of a horizontally suspended stem with only one leaf on the under side, the stem will show geotropic curvature if the leaf is in the apical node; but will show as a rule no curvature if the leaf is in the basal node; or a slight curvature in the neighborhood of the basal node may occur after considerable delay.

8. All these experiments agree with the assumption that each leaf sends a current of root-forming substances towards the base of the stem, and a current of shoot-forming substances towards the apical end of the stem; that the root-forming substances have a tendency to collect at the lower side of a horizontally suspended stem, and that they are associated or identical with the substances causing the growth of the cortex on the lower side of the stem to which the geotropic curvature is due.

9. This idea is further supported by experiments with stems split into two longitudinally. If such split stems are suspended horizontally only those halves show geotropic curvatures whose cortex is below. If the cortex is above (and the cut surface of the stem below) almost no geotropic curvature takes place, no matter where the leaf is, for the simple reason that such stems are lacking the cortex on the lower surface. If the cortex is below and one leaf left at the apical end, root-formation will take place just as rapidly as in the intact stem and geotropic curvature still more rapidly (since the passive resistance of the upper half is removed). If, however, the leaf is left at the basal end, in about 50 per cent. of the cases no geotropic curvature takes place, or if it takes place it is confined to the region of the basal node; and is considerably less than if the leaf is left at the apical end.

If the pieces have no leaf they will bend more strongly than when a leaf is left at the basal end only, thus indicating a possible inhibiting influence of the basal leaf upon the curvature in the more apical regions of the split stem.

10. All these facts suggest a close association if not identity between the root-forming substances and the substances (or hormones?) causing geotropic curvatures. Such a close association or identity between organ-forming and geotropic substances might also explain why it is that in some cases geotropism can restore the form in the same way as does regeneration, as, *e. g.*, in certain fir trees, where one of the upmost horizontal branches will begin to grow vertically when the apex is cut off.

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THE AMERICAN CHEMICAL SOCIETY

THE 52d meeting of the American Chemical Society was held at the University of Illinois, Urbana-Champaign, April 17 to 21, 1916. The meeting was an unusually enthusiastic one, the total registration being the largest to date, namely, 728. A detailed description of the social and other events of the meeting will be found on page 396 of the *Journal of Industrial and Engineering Chemistry* for May, 1916. The general meeting and meetings of the Divisions of the Society were held in the lecture rooms of the chemistry building of the University of Illinois. Some notable features were presented in the "Special Program for Home Economics" by the Division of Biological Chemistry; in the "Symposium on the Activated Sludge Method of Sewage Purification," by the Division of Water, Sewage and Sanitation, and in the "Symposium on the Chemist in Food Control," by the Division of Agricultural and Food Chemistry.

The following general addresses were given:

The Composition of Corn as affected by Nineteen Generations of Seed Selection: L. H. SMITH. (Lantern.)

The Manufacture of Chemical Apparatus in the United States: ARTHUR H. THOMAS.

The War and the American Chemical Industry: RAYMOND F. BACON.

On the Influence exerted by Electrolytes on the Equilibrium of Emulsions, Jellies and Living Cells: G. H. A. CLOWES. (With demonstration.) (Lantern.)